OpenTrack simulation for suburban tunnel in Paris (RER B & D)

Presentation
Opentrack – Viriato workshop
January 24th, 2008
Zurich, Switzerland
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- Overall context
- Main technical data
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1. Introduction: Dense transport network

Inside Paris

- **Underground**: 16 lines (1 automated), 211 km, 300 stations

- **Regional trains** crossing the city: 5 lines, 31 stations
1. Introduction : Project location

Gare du Nord + Châtelet les Halles : 2 major nodes in the Paris transport network
2. Overall context

- Operating problem:
  - Convergence of 2 overcrowded lines on the same double track tunnel
  - Regularity and customer satisfaction declining
  - Choices to be made by the Transport Authority to improve fluidity

- Client: Syndicat des Transports d’Ile de France (STIF)
  - Transport authority of Ile de France region

- Technical partners: the operators running trains in the tunnel
  - RATP (Paris region transport company) ➔ southern part of line B
  - SNCF: National railway company ➔ northern part of line B & line D

- Support: Mr Huerlimann – OpenTrack GmbH
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- Timetable: 32 trains per hour per direction = 20 trains line B + 12 trains line D
- Headway: 90 seconds, theoretical headway < 90 sec
- Two controlling stations (RATP & SNCF)
- Two types of rolling stock
- Two electrical power supply systems (change at Gare du Nord)
- Driver change for line B at Gare du Nord (change between RATP and SNCF)
- Use of an « extra track » in Châtelet station, called « voie Z » by line D.
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Focus on station: Châtelet-les-Halles

(north) La Plaine Stade de France ↔ St Michel Notre Dame (south)

(north) Stade de France – St Denis ↔ Paris Gare de Lyon (south)

Not simulated
Dedicated tracks in the station – No interactions with lines B & D
3. Main technical data

Focus on station: Gare du Nord

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(north) Stade de France – St Denis ⇄ RER D ⇒ Paris Gare de Lyon (south)
4. Major stakes

- Dense traffic ➔ one of the most heavily occupied railway sections in France
  - 32 trains per hour and per direction
  - Gare du Nord + Châtelet les Halles: 2 major nodes in Paris network

- Signalling system in the tunnel
  - Classic signal system: fixed block 3 aspects signalling
  - Continuous Speed Control ➔ acceleration authorised before signal sighted
  - Different driving behaviour between SNCF and RATP personal

- Change of conductor in Gare du Nord
  - Dwell time: 2 minutes in reality, instead of 1 minute in timetable

- Major goals for regularity
  - Intention of Transport Authority: allowing more trains on the line each hour
  - Today: every peak hour, 2 trains cancelled by direction
5. Before simulating: Present situation

Diagnostic and analysis of present operations, normal situation without major disturbances

- **Theoretical timetable**
  - Number of trains
  - Different headways (ex: a train every 3 min for line B)
  - Identification of peak hours

- **Real operating data (statistics concerning a representative period)**
  - Distribution of delays on arrival at stations
  - Distribution of dwell times
  - Use of track Z in Châtelet station
  - Headways between trains

- **Site visits**
  - Tracks
  - Interlocking posts
  - Cab rides

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32 trains p.h.p.d. in theory

25 trains p.h.p.d. in reality
5. Model calibration chart

Data measured during target period of reference
20 days from the 4th to 29th September 2006

- **Departure delays** measured in
  stations surrounding the main study zone
  (departures toward study zone)

- **Arrival delays** measured in
  stations surrounding the main study zone
  (departures toward study zone)

Analysis
Identical results vs. measured values?
(i.e. within tolerances)

YES
NO

**OPENTRACK**

- **Modelling**
- **Calibration iterations**
- **Model calibrated and validated**

Input data (entering delays in the practical modelling zone)

- **Simulation**
- Results from simulating the present situation
5. Before simulating : Model calibration

- Basic definition
  - Infrastructure (tracks, station platforms, speeds, signals, routes settings)
  - Rolling stock (types and performances)
  - Timetable

- Calibration method
  - Extended peak hours, 06.00 - 10.00
  - Filtering of circulations: from 5560 trains planned to 4920 trains used (data considered reliable)
  - 20 simulation runs

- Calibration criteria
  - Shortened peak period: 07.15 - 09.15
  - Filtering of circulations: from 4920 trains to 2145 trains in that specific period
  - Delays on arrival at stations (Average, standard deviation, correlation)
5. Before simulating : Reference

- Based on the calibrated model
  - All trains within the theoretical timetable
  - Infrastructure unchanged
  - Modification of injection rules for line B South > North

- Evaluation criteria of reference (also used to evaluate scenarios)
  - Peak hour capacity
  - Overall delay for each line, end of main study zone
  - Mean delays + standard deviation
6. Simulation in several steps: scenarios

- Modelling of the following parameters, according to the scenario
  - Infrastructure
  - Initial delay (piecewise linear distribution)
  - Timetable and dwell times
  - Rolling stock

- Visualisation on screen ➔ check of correct modelling

- Simulation: 20 runs for each scenario, without visualisation

- Statistical analysis
  - « OT_timetablestatistics.txt » file, wasn’t helpful, only the last run recorded
  - Our partner, Mr Huerlimann developed a new file with the listing of 20 runs
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6. Outputs ...
7. Interesting scenarios

- **Short term scenario : Turnaround at Châtelet-les-Halles using track Z**
  - Line RER D : lower traffic in the tunnel
    - 4 trains / 12 stop at Châtelet les Halles, on a dedicated track (voie Z)
    - 8 trains remaining in the tunnel each hour
  - Line RER B : all trains continuing in the tunnel (20 each peak hour)

- **Short term scenario : Suppression of driver change**
  - Only line B concerned, today both operated by SNCF and RATP in their perimeter
  - Harmonization of driving behaviors in the tunnel (start on « yellow » warning signals)
  - Reduction of dwell times for RER B in Gare du Nord (= Châtelet times)
7. Interesting scenarios

- **Mid term scenario: Automated driving**
  - All trains runned following ATP rules in extended perimeter (cf. SACEM system)
  - Modification of Perf. on time: 100%
  - Running times and dwell times unchanged
  - Block shortening + added signals

- **Rail switch in Gare du Nord**
  - > South: allowing RER B on tracks originally dedicated to RER D
  - > North: possible track interchange for both line
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  - Adding priorities
8. Conclusion

- Specificity of the study
  - 40 modelled scenarios with OT (27 « officially » ordered by client)
  - A 18 months study, 6 sessions of simulation
  - OT : a tool for consensus between authority and operators
  - Statistical approach of the problem

- Possible improvements
  - Different boarding-unboarding times according to rolling stock
  - Interface with other simulation software (i.e. : Simwalk)
  - Definition of crowds on platform : impact on dwell times
Thank you for your attention !!!
I’m available for your questions
Brief history of line RER B and RER D

- From 1846: historical « ligne de Sceaux » ending first at Denfert-Rochereau, later at Luxembourg,
- 1977: continuation under the Seine river, until Châtelet les Halles,
- 1981: opening of the Châtelet – Gare du Nord tunnel
- 1983: junction with Roissy-Rail airport courses and the Mitry – Gare du Nord line = today’s line B

- 1987 ➔ 1990: trains coming from Villiers le Bel, Goussainville and Orry la Ville stopping first at Gare du Nord, extended at Châtelet les Halles (via existing tunnel)
- 1995: opening of the Châtelet – Gare de Lyon underground section, trains heading toward Melun, La Ferté-Alais and Malesherbes
- 1998: opening of Stade de France Saint-Denis station
Rolling stock involved in the tunnel

- Date of construction: 1980-1983
  - V max: 140 km/h
  - Max passenger capacity: 843 p.
  - Length: 104 m
  - Weight: 283 T
  - Concerned line: RER B
    (also running on line A)

- Date of construction: 1988 - 1998
  - V max: 140 km/h
  - Max passenger capacity: 1413 p.
  - Length: 129 m
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  - Concerned line: RER D
Ile-de-France regional rail network

- Réseau Express Régional
- Strong and identified network
- Paris underground cross-over
- 2 operators: RATP + SNCF

- SNCF operation (Transilien)
- Basic commuter lines
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PARIS
7. Other scenarios – selected list

Basic scenarios

- Equal RS performances for both lines
- Modification of line D headway
- 2\textsuperscript{nd} tunnel between surrounding stations
- Modification of injection following improvements outside perimeter

Combined scenarios
What is Egis Rail?

Europe’s major financial institution, N°1 French financial group

A French consulting, engineering and operating firm, dedicated to development infrastructures

Rail and transit consultants and engineers, formerly named SEMALY, created in 1968

Covering all types of transport projects

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For the benefit of

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Egis Rail ? References

METRO

LYON: whole network
(line D, fully automated)

Marseilles: extension of the network

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Stade de France St-Denis
La Plaine Stade de France
Gare du Nord + Châtelet les Halles
Gare de Lyon
St-Michel-Notre Dame
Tour Eiffel
Arc de Triomphe
Notre Dame
Louvre
Montmartre
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Situation de référence

Scénario 2 : suppression de relève conducteur

Sens Nord > Sud Châtelet-les-Halles – ligne B

67% 33%
5 min

25% 75% 33%
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OSENTRACK

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特定性

- 40 模拟场景与 OT（27 « officialy » 经客户点名）
- 18 个月研究，6 次模拟会议
- OT：一种工具，用于权威和操作员之间的共识
- 统计问题的解决方案

可能的改进

- 根据运行车辆的不同，不同的上车-下车时间
- 与其他模拟软件（i.e.：Simwalk）的接口
- 平台上的人群定义：影响停留时间
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- Concerned line: RER D
Ile-de-France regional rail network

- Réseau Express Régional
- Strong and identified network
- Paris underground cross-over
- 2 operators: RATP + SNCF

- SNCF operation (Transilien)
- Basic commuter lines
- Terminus in 6 main stations
- Possible shared trunks with RER lines
7. Other scenarios – selected list

- Basic scenarios
  - Equal RS performances for both lines
  - Modification of line D headway
  - 2nd tunnel between surrounding stations
  - Modification of injection following improvements outside perimeter

- Combined scenarios
What is Egis Rail?

Europe’s major financial institution, N°1 French financial group

A French consulting, engineering and operating firm, dedicated to development infrastructures

Rail and transit consultants and engineers, formerly named SEMALY, created in 1968

Covering all types of transport projects

- Metro
- Light Rail Transit
- Conventional Rail
- High Speed Lines

For the benefit of

- Ministries of Transport
- Regional or City Authorities
- Operators
- Private Consortia, etc…
Egis Rail ? Range of services

- Planning studies, Consultancy and Audits
- Design
- Procurement assistance
- Construction management and supervision
- Manufacturing control
- Testing and commissioning
- Maintenance management
Egis Rail ? References

**METRO**

**LYON** : whole network (line D, fully automated)

**MARSEILLES**

Extension of the network
Egis Rail ? References

LIGHT RAIL TRANSIT

**DUBLIN**: Technical Design & Construction Management

**OPORTO**: integrated engineering within a private Consortium

**KRAKOW**: design assistance and construction supervision